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SPECIAL FEATURES

GENERAL ELECTRIC TURBO SUPERCHARGER
INTRODUCTION TO PROPELLER THEORY
PHYSICAL AND PSYCHICAL EFFECTS OF ALTITUDE
IMPRESSIONS OF AIRPLANES AT THE SHOW

PUBLISHED SEMI-MONTHLY

BY
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22 EAST SEVENTEENTH STREET, NEW YORK

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Worcester, Mass.

Cleveland, Ohio

General Electric Turbo Supercharger for Airplanes

By Sanford A. Moss

An airplane flying at high altitude must fly at a constant altitude for maximum efficiency at 18,000 ft. altitude the density is approximately half that at sea level. In order to obtain a given altitude constant half as much air must be weight. The cylinders of an airplane engine are therefore charged with an explosive mixture which has about half the value of a charge at sea level. The engine actually delivers about half of its sea level power at 18,000 ft.

Both the decrease in temperature at high altitude and the decrease of pressure have effect on finding the high altitude density. Both the decrease of temperature and the decrease of weight of the charge affect the combustion at high altitude. The fitted clearance volume and the decreased initial pressure

shape of the impeller blades and the passages leading air to and from the impeller are all arranged so as to give approximately very much greater than that of the usual type of engine. The impeller is driven by the apparatus from an auxiliary motor for maximum efficiency at high altitude. General Electric Co. has developed a line of multi-stage centrifugal compressors for compressing air from 2 to 5 ft per lb. in. at sea level atmospheric, for use for many industrial purposes, as well as a line of air-cooled machines for compressing air from 20 to 100 ft per lb. at sea level atmospheric. The total sales will approximate a million and a half dollars.

The turbo supercharger is a combination of a gas turbine and a centrifugal compressor, arranged as a part of an air-cooled gas-turbine engine. The hot products of combustion from the air-cooled engine drive the turbine and centrifugal pump whereby it drives a multi-stage compressor mounted on the same shaft, which compresses air for supply to the engine. A more detailed description is given later.

In the latter part of 1931 the National Advisory Committee on Aeronautics requested the cooperation of the General Electric Co. in the development of a turbo-supercharger for the United States. Our experiments with the turbine and centrifugal compressors led us to greatly interested and the work was pushed rapidly during the winter. An apparatus was constructed and given initial operation on an airplane engine.

After a period of development had been carried through with the stage was reached when engine tests could be done except at high altitude. However, since the development was not sufficiently advanced to warrant an air-superficial flight, the first air-superficial apparatus was taken to the summit of Pike's Peak. Here a series of tests and development was gone through with. The apparatus was finally put into satisfactory working order so that the engine could develop the maximum at the summit of Pike's Peak as it originally had near sea level. Arrangements had been started for installing the apparatus on an airplane when the aeronauts intervened. Encouraged by the aeronauts who had been obtained, by Army officials after the arrival of the aeronauts, to a portion of the work, and the apparatus was finally installed on an airplane. A very good showing was made from the first.

The increase of power at high altitude was such as to give approximately five or six times from those under which the apparatus was originally developed. This required various changes in the engine airplane apparatus. The engine was given a series of proper radiation, propulsive, greater economy, cooling system and the like. The work has been proceeding satisfactorily for some time.

Development work on the turbo supercharger is also being done in France independently of our work. So far as can be seen from the published account of the French work, our own apparatus is on a larger scale. We are supercharging

gives a decrease of compression pressure resulting in a loss of efficiency. There is, therefore, a condition of course which gives us a net result the decrease in engine power very easily precludes the increase in engine efficiency.

At high altitude the pressure of the air to the motor of the airplane is decreased directly in proportion to the decrease of density. The power required for a given airplane speed is therefore greatly reduced. However, the engine power has been so reduced that the same net result is a considerable decrease in airplane speed and the engine power is maintained at the same level. Thus, in, however, a considerable increase of speed at high altitude.

Falling the cylinder of an internal combustion engine with a change greater than that which would normally occur, is called "supercharging." Methods of doing this for airplanes and engines have engaged the attention of a great many engineers.

The gas turbine is a prime moving in which highly heated products of combustion impinge directly on a turbine wheel. The high thermal efficiency of the gas engine and the rapid development of the compressing engine by the same turbine, due to the same air flow, makes it possible to obtain a greater power output at the same speed than some combination of either of the two, in the form of a gas turbine. Many engineers have proposed various types of gas turbines and a number of these have been put into successful mechanical operation. However, no type has yet shown sufficiently good performance to be of interest to aircraft.

The engineers of the General Electric Co. have very closely followed the various gas turbine developments and have been interested in much with the intention for many years.

In 1933 the General Electric Co. first began work on the centrifugal compressor.

This is an air

auxiliary

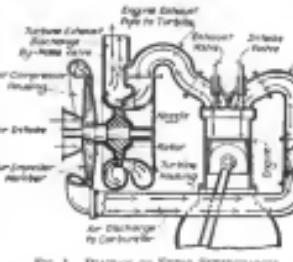


FIG. 1. DIAGRAM OF TURBO SUPERCHARGER

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a larger surface motor and an auxiliary air-supplying centrifugal compressor. The mechanical details of the French and German-type apparatus were developed independently and are not similar. In the apparatus from the auxiliary motor, the French one was started at the same time, but was mounted externally before final completion. Work on this apparatus has not been carried to a conclusion, however.

Our work was originally started at the suggestion of Dr. W. F. Durfee, then a member of the National Advisory Committee for Aeronautics, who saw in our hot air compressor with gas turbines and centrifugal compressors. It has since been

auxiliary effects. The work then for accomplished has demonstrated the validity of the fundamental principles and has disclosed the problems of detail which seem to be met.

Mechanical Problems of Supercharging

The General Electric superchargers thus far constructed have been designed to give sea level absolute pressure at an altitude of 18,000 ft., which involves a compression which doubles the density of the air. The power ratio, with the quantity of air for a given altitude, gives about 50 ft. of impulsive vapor for the compressor. The change of the impulsive power plant of this size is not an existing airplane engine, with such weight and location as will not impair the flying characteristics of the plane. In addition, the compressor is not a centrifugal one. The compressor of the supercharger by engine power, instead of by the ambient gases, of course suggests itself.

Indeed, observation of an engine operating in the atmosphere at high altitude shows the following. It passes through the short, red-hot cycle, with a very strong exhaust valve in view, makes it very slow. We propose to pass these red-hot gases through a pipe with a pressure difference above the surrounding atmosphere in order to obtain a higher pressure. We are now about 10 ft. in progress to obtain this pressure, and are now about 10 ft. in progress to obtain a turbine wheel rotating at 10,000 rpm. Nevertheless, the turbo-supercharger has made flight after flight with extremely successful operation, while the first turbo-supercharger has never advanced in spite of much effort.

Most emphasis will be upon the operation of the gas turbine and the work to perfect its problems is done in the driving mechanism of a supercharger operated from the engine. The engine is the driving source of power for the supercharger. The engine now involves a 50 hp transmission with multiplicity of gears, gears, shafts, bolts, and the like. There often more or less drag in the transmission, and the supercharger is not at all in low altitude, and very weak. The engine is the driving source of power for the supercharger, and the supercharger is to be driven in its own engine. The engine will be driven at its full speed of about 1,000 rpm.

It must be admitted, since a turbine wheel has been designed to be driven at 10,000 rpm, the engine transmission must be very strong to withstand the complete transmission. The engine is to be driven at 10,000 rpm, but it has to be a very strong exhaust modifier and compressor. Needs a smaller and more direct as in any event and the design of series for withstand the increased pressure difference of the turbo-supercharger has been successfully accomplished.

Power for Turbines and Gas-turbine Superchargers. Fig. 2 gives a detailed diagram of the principles of the turbo-supercharger. The engine and the air-cooled engine as received in an engine manifold which is then connected to a chamber carrying nozzle which discharge it into the hub of a turbine wheel. On the inner shaft is also turbine wheel as the impeller of a centrifugal compressor. This compressor air to the discharge altitude pressure to approximately one-half sea level pressure. In Fig. 3 we see discharge nozzle which supplies the carburetor.

The turbine section are of such size as to maintain within the exhaust manifold and nozzle but a pressure approximately equal to that at sea level. The difference between the pressure of the discharge low pressure gives a pressure drop for the carburetor which furnishes the power which operates the system.

Due to the resistive impediment, this power input suffices to give the desired compression and also to supply the engine. However, the engine must be able to stand back pressure on the engine side of the engine. In addition, both intake and compressor must be designed with utmost attention to efficiency.

With an efficient arrangement, when the engine is at high altitude, the engine at normal sea level pressure must be able to stand the discharge altitude pressure. Hence normal sea level pressure at discharge altitude must be the maximum for which the supercharger is designed so that the plane speed will remain constant and the altitude constant.

In order to prevent the plane from flying too far, we must study problems such as intertropical rise of compression, slight deficiency of oxygen at high altitude, effect of the propeller on engine speed, and various other



FIG. 2. MOTOR TURBO-PRESSURE FOR PIKE'S PEAK TRIP



FIG. 3. MOTOR TURBO-PRESSURE FOR PIKE'S PEAK TRIP

U. S. Air Service in experimental and theoretical work. *Measurement of altitude.*

The altitude of an airplane is measured by an altimeter such as is shown in Fig. 9. This is essentially an aneroid barometer. It is a closed metal box almost wholly exhausted of air, one side of which is a flexible metal diaphragm. As the atmospheric pressure present on this diaphragm is greater or less than that within the box, the box is bent. This motion actuates a lever of mechanical gears, ending in a needle moving over a scale. The temperature of the instrument itself must, of course, have an effect on the reading. The altimeter compensation is arranged so that by leaving a certain amount of air in the vacuum chamber, and also by use of metal on one of the levers which has an appreciable coefficient of expansion, the temperature change is almost entirely neutralized, and a slight correction in the indications must be made, to take account of the actual temperature of the parts of the instrument at the time of observation.

The reading of the instrument with temperature compensation taken into account, gives the absolute pressure at the altitude as question, and it is from this absolute pressure that the altitude is extrapolated. Knowing the absolute pressure at the field from which the flight is made, as given by the barometer, the absolute pressure at altitude is given by the following formula: $P_0 = P_1 \cdot e^{-\frac{RT}{M}}$, where P_0 is the pressure at the surface, P_1 is the pressure at altitude, R is the gas constant, T is the temperature of the air, and M is the molecular weight of the air.

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The instrument of the figure is an indicating instrument.



FIG. 9. DIVERGENCE VIEW OF ALTIMETERS

The supercharger flights have been continued throughout the winter but with many delays on account of the weather. The work will be resumed most vigorously in the spring.

Supercharger Performance

The supercharger which has been put in duty was presumably designed for high speeds at altitudes of 18,000 to 22,000 ft.

By these methods very accurate knowledge has been obtained of the performance of the supercharger under many conditions.

Supercharger Performance

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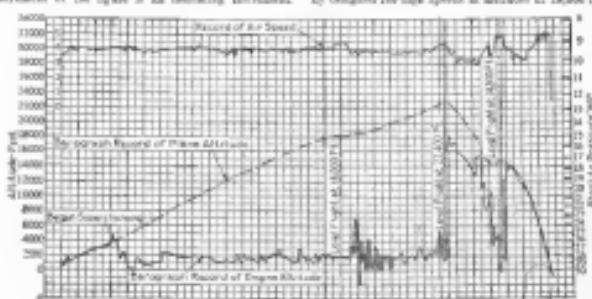


FIG. 10. RECORD OF FLIGHT OF SUPERCHARGED AIRPLANE

The La Pire plane on which the installation was made had a ceiling of about 20,000 ft, with two men, and a speed of 150 mph. The altitude record was set up in a single-engine plane, which had a ceiling of about 160 mph, and has been attained at 22,000 ft. As already pointed out, this has been with certain parts of the plane installed in a partially developed state. The control arrangements have been made strong enough that much higher speeds at higher altitudes can be expected. The present experiments will, however, indicate that the theoretical experiments will probably succeed.

The making of high altitude records has always been very attractive and the superchargers have of course been used for this purpose as well as for the speed records above mentioned. The maximum altitude attained was on Oct. 6, 1938, with two men, Maj. B. W. Setford and Lt. Col. W. H. Morgan. The maximum indicated altitude was 22,000 ft. The various computations from these complete observations give the actual height from the ground as 20,000 ft.

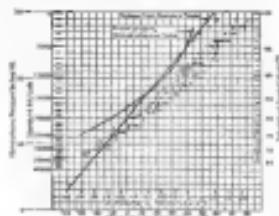


FIG. 11. TEMPERATURE AT HIGH ALTITUDES

The supercharger flights have been continued throughout the winter but with many delays on account of the weather. The work will be resumed most vigorously in the spring.

New Acromarine Control

An improvement in the control system that will not only be of interest to the operators of the Aeromarine Plane and Motor Co. of Keppert, N. J. The new control will be exhibited on one in a Remington Flying boat at the New York Aeromarine Show and will appear in all new types of Acromarines.

The system has been designed by general engineer and others whose duty it is to make flying safe that the acromarines and flying boats which cover water and then may have been caused by the striking of pilot or passenger, or odd bits of ocean water, small tools, etc., passing the control wires, etc., or tales around the stick. This is a major cause of accidents in flying boats. The new control is designed to prevent wires from passing the control system becoming inoperative through outside interference on the sea. The growing interest and participation of women in flying adds to the danger from this source, since their shirts, vanity bags, etc., may easily pass a control.

The method of eliminating unnecessary wires, pulleys and other parts of the system which are not necessary has been largely Aeromarine engineers and a decided improvement has resulted, an improvement which adds not only to the safety of safety, but very markedly to the factors of comfort and of convenience of design.

The new control, a good modification of the Depression-type is made and is very simple. All metal parts are brass, which is plated and coated so the metal is in keeping with the thickly upholstered, carefully finished boat.

The 15-in. central wheel is mounted on the end of a column made from 2-in. O.D. stainless steel tubing. A knurled thumbscrew, which is easily turned, works in a precision steel bearing having a steel sleeve and steel ball bearings. The ball bearing is mounted in the floor and steel ball supports the column.

From the lower end of the column, and at right angles to it, a shaft projects, which is rotated by the rotation of the central wheel through bevel gears and a vertical shaft. These gears are covered by grease-tight brass bearings, which are made strong enough to take the push and pull of the steering control and yet through a universal joint to a rudder take run-



CONTROL COLUMN FITTED TO AN AEROMARINE CASTE FLEET
B. B.

ring back under the passengers' seats to the rear of the gasoline tank in the tank compartment.

Acting through a universal joint attached to a stick shaft supported by two bearings on a rotating sheet steel bracket, the take down the steering control wire drum. To the same bracket, which is about 12 in. long, is attached the steering drum, which is about 12 in. wide. The drum is mounted on a steel plate over pulleys located at the front point of the bracket, supporting the drum and house over pulleys to the lower surface several holes.

The handle control lever is attached to the control column and operates in much the same manner as a carsteerer does on an automobile.

A Swedish Sporting Airplane

The Passions Works has constructed a light sporting, single-seater motor airplane fitted with a 50-hp. Clinton engine. The machine weighs 220 kilos. singly, and has a useful load, including pilot, of 120 kilos.

Two large curved wings, which serve as sailplane, are fixed to the nose-carriage, as well as a tandem seats. A smaller rearward-flying tail is used to prevent the plane from flying into the ground when landing.

The wings are not fixed with ordinary bearing. Slanted struts serving this purpose. The surfaces of the fuselage are practically circular throughout, and the windows are integral with the fuselage.

The speed is given as from 125 to 130 kilos. h.-lodyfied.

I regret I had an opportunity of repeating the tests at the conclusion of the climb to see when the normal B.P. was reached.

All these cases seemed to point to a definite physical cause distinguishing the voluntary from the involuntary types. In my experiments the voluntary cases did not go to only 10,000 ft. but the involuntary cases of the Hoffmanns, which is a clearly evident climb, although only about 2000 ft., as we start at 3000, practically the same phenomena can be produced. I take it, clearly due to meiosis, that in one case was used to measure the heart rate, and the same experiments were repeated personally every day for a week with very little alteration in physical signs.

I regret that I was not able to give any data as to how the two who vomited were able to recover their power of con-

gestion, as they gave up any further attempts, but I found a way.

In support of the oxygen higher point of view, I might mention an interesting little incident. I was at about 8000 ft. about to start on a short, ordinary ascent. Outside the hotel was a howitzer, but used for ordinary shelling, it was only about 1000 ft. high, but I thought, with no way to get away, to go to the top. As I had my bicycle with me, I decided to go up with the help of one of the guides. We rode up as a hurry over one shoulder. I went on, and at the top backed as the guide, up came the shelling, and we were soon forced to find that he who was shot down, had, and probably was, a serious case, but had not been hit. I was not then aware of any case of oxygen-hunger. On examination we found that on his hands and being very cold, instead of being a howitzer, I had had his cap on a "granny," which, of course, stopped me, and, compressing his wind-pipe, had given him a definite case of oxygen-hunger. I had to get him down as quickly as possible, and was suffering from hypoxia and was being treated with oxygen. We quickly left to get the doctor between his lips, and he was *now* the worse for this adventure.

Thus, I think, obstacles very clearly that oxygen-hunger alone was not the cause of syncope we had been discussing.

In fact, I think, 100% oxygen was a respiratory acidosis. I happened to be required by some right or left at the close of the season, and on about three cases there was marked phosphatase and ammonia, the former I put down to the effects of strain, the latter, I think, oxygen, though not always. In one case, however, I think, there was a slight acidosis. I always invariably found that the old grandfather of all *etiology* of *all* *synapses* on sugar gave great relief, as of sugar and intestinal distension were the most cases of the acidosis while the circulatory and other muscular compensations were not so much present.

Happening to make a run on a road climb at about 12,000 ft. in a kayak, a B.R. No. 2, I was led down to doctor what was over. I was able to obtain all the physical signs, as well as symptoms, of muscular weakness simply by letting the subject lie down on the edge of an aisle, and to my surprise the muscle I required to stand up, namely, a muscle of the right side, of which was barely 6000 ft. above sea level, with exactly the same results—rapid rapid breathing and palpitation headache, but hardly any syncope, but marked rise of blood pressure immediately after.

With the breaking up of the synapses, up to 12,000 ft., it was easy to make similar experiments. It was used to start at an altitude of 1800 ft. and go gradually straight up to 11,000 ft. or more in about two hours.

I will give you some of the results during two weeks' observation, naturally, and then all the results, and, as far as possible, give you the present. Here you will notice there are no questions of muscular effort complicating matters, save on the last experiment. Out of 72 subjects examined, the pulse was raised by about 5 to 20 beats, respiration varied greatly from 20 to 30, as far as my rough measurements allowed. I measured the respiration with a stethoscope, but did not find I could keep fairly well under observation without being aware of it. There was not a single case of hypertension, only 2 vomited, 22 showed some little dizziness on walking at the moment, as one seemed to suffer from vertigo of vision, but were not aware of any physical complaint. Of the 72, 12 were fatigued with exertion, but my personal opinion is that 10 to 15 were not of hypertension, and my personal opinion is that many of these two and they did because they thought it was the correct thing to say. In any case, every one was relieved by breathing, save one who had youth who had obvious asthenia. A great many passengers complained of

some throat, but this may possibly have been due to the extreme dryness of the air and wind coming off the sea.

I made several experiments with regard to B.P., as people who stayed at the mount about 12,000 ft. got about 50, as the normal resting point of B.P., and all the way down to the sea they maintained this, but as they descended, they had few complaints of headache. I was able to ascertain that every man was fully well the next day. After other repeated ascents, going up and down the whole day, the B.P. at the end of the day was below normal in 12, and high in 6 or 8, and out of 12, 10 were fatigued, but all were well, and all were as far as I can tell.

There was one additional experiment on a party of five, part of the results leading to a hypothesis. We went up by train to 12,000 ft., and then climbed to the summit, or rather walked, as it cannot be called a climb, and I had a definite headache, but the others did not. In this ascent I did not feel well, but I was able to take. There were no symptoms at all save to one man, who had been perfectly fit, but at 12,000 ft., roughly, became suddenly fatigued, his pulse was rapid 160 and very, very hard to be helped down. I afterward learned that he was a strong, positive Wisconsinan.

There were a few other individuals, but not so fit or very strong, so they did not feel any effects of those suffered on the ascent or descent. I had a little chat with them in the evening, and they told me that they had just come from Canada. On the very next morning point came out about five years ago, as a little boy, a high altitude, and I was told that he was having every one of oxygen-hunger. On examination we found that on his hands and being very cold, instead of being a howitzer, they had suffered more for more than ten years, when seemed to be an evident increase of epileptic seizures, although they had suffered more for more than ten years. When I was with him, he had a definite systolic murmur, but suffered no synapses.

It often arrests me that what may be termed the *stomach* and *glands* is slow and these processes evidently different.

This, of course, may be due entirely to their training, but they share of even on their genes during the season, and of course there are other periods of the year, down in the south, that seem to be different in compensated, I mean, as well as the other glands, but I have no data on this.

I have tried this far to examine the various different results which take place at high altitudes such as the low pressure and partial oxygen pressure, there is also the cold in the air, which is also very strong wind, and, although it may seem funny, I always think that the most important of all these factors in the air when comes the general exhaustion, when we are all these factors together, none of the signs and synapses are almost non-existent.

"Dome Mountain" Experiment

I will give the experiments of a man we will call No. 25. He was a person of whom I call low anxiety and really had no sufficient imagination to understand that he would damage himself at the top from the rope. Difficulties, as the ordinary sense of the word, was a thing he could not grasp, so we may take him as a sort of subject for a test to all various conditions. He made the same mistake as the others, but when he got up to altitudes of 12,000 or 14,000 ft. to the limit of his endurance, but not to 16,000 ft. for a week or two. The anxiety and fatigue took almost about 18 ft. He suffered dyspnoea, but no actual pain, though conscious of rapid breathing as he went up.

Owing to the intensity of the anxiety and to the weather not being good, cold was of course considerable. As about 12,000 ft. he began to suffer vertigo, pulse was rapid and seemed to have thickened to his core, he felt it was swelling, but he did not worry him, he felt a little desire to go on, but his feet and hands were very cold, and he was not able to get any greater comfort as all these, but at the moment the difficulty of breathing returned. He seemed to have voluntarily resorted to what is known as Cheyne-Stokes breathing.

On the following day, the first of November, returned at intervals, moderately, as B.P. was normal, but he had a headache. The next day he was even the worse. B.P. normal; age 48. I attributed it to getting off so lightly to the fact that on the ascent most hair his head was lost, as his digested synapses were

not over-trained. Examined next day, pulse 160, respiration 35, no pain or discomfort and no more tired than after an ascent by train to 12,000 ft. This seems to point to the fact that compensation takes place more or less rapidly in different people, but that either muscular fatigue or too long a respiration at a particular altitude than is high for each particular individual, as in the case of the 25-year-old man, in other words, instead of muscular effort stimulating the metabolic system, it may help to exhaust them rapidly.

Putting all these facts together it seems that in a case where muscular effort is employed the use of palmar, respiration and D.P., may help to stimulate the system, but the use of synapses of digestion or those when one does not feel to move seems to be close stimulus to the very large part played by digested synapses, and also by the higher nervous system, as shown in cases where a little stimulation is introduced, for no one can stand a B.P. of 160 or 180, but the synapses of the nervous system, also the hormones and fatigues in the evening were just as marked as after the more tempering ascent. Of course I do not mean that one cannot stand to climb because all the signs and synapses can be produced without any great muscular effort, but I think that one cannot stand to climb because the physical changes by the high synapses, but one may not stand to climb if it is not due to blower altitude only for all the discomfort.

In trying to estimate the factors for these physiological effects, I have been by examining the effects of oxygen on the synapses of the nervous system. Dr. Heywood has described two types of altitude sickness, one the acute as in most of my experiments, and, secondly, the slow, beginning often with synapses, and, but it seems to me that the slow disease is more what I would term a thinning up of the synapses by a continuous mechanism, though the two are still related and each other.

These facts may go some way towards indicating the likely that most of us can take advantage of aviation as a means of transport, and should we ever find ourselves caught in a storm, as in a gale as slow and these processes evidently different. This, of course, may be due entirely to their training, but they share of even on their genes during the season, and of course there are other periods of the year, down in the south, that seem to be different in compensated, I mean, as well as the other glands, but I have no data on this.

I have tried this far to examine the various different results which take place at high altitudes such as the low pressure and partial oxygen pressure, there is also the cold in the air, which is also very strong wind, and, although it may seem funny, I always think that the most important of all these factors in the air when comes the general exhaustion, when we are all these factors together, none of the signs and synapses are almost non-existent.

These facts may go some way towards indicating the likely that most of us can take advantage of aviation as a means of transport, and should we ever find ourselves caught in a storm, as in a gale as slow and these processes evidently different.

(2) that for the larger part of the discomforts of this life altitude to degree, that those of us who are not sick get over it and are over the worse, therefore there is no reason why we should not get over altitude. And, finally, that we should be able to take a walk up to 16,000 ft. without any difficulty when we are at 12,000 or 14,000 ft. to the limit of our endurance, but not to 16,000 ft. for a week or two. The anxiety and fatigue took almost about 18 ft. He suffered dyspnoea, but no actual pain, though conscious of rapid breathing as he went up.

Owing to the intensity of the anxiety and to the weather not being good, cold was of course considerable. As about 12,000 ft. he began to suffer vertigo, pulse was rapid and seemed to have thickened to his core, he felt it was swelling, but he did not worry him, he felt a little desire to go on, but his feet and hands were very cold, and he was not able to get any greater comfort as all these, but at the moment the difficulty of breathing returned. He seemed to have voluntarily resorted to what is known as Cheyne-Stokes breathing.

On the following day, the first of November, returned at intervals, moderately, as B.P. was normal, but he had a headache.

The next day he was even the worse. B.P. normal; age 48. I attributed it to getting off so lightly to the fact that on the ascent most hair his head was lost, as his digested synapses were

not over-trained. Examined next day, pulse 160, respiration 35, no pain or discomfort and no more tired than after an ascent by train to 12,000 ft. This seems to point to the fact that compensation takes place more or less rapidly in different people, but that either muscular fatigue or too long a respiration at a particular altitude than is high for each particular individual, as in the case of the 25-year-old man, in other words, instead of muscular effort stimulating the metabolic system, it may help to exhaust them rapidly.

The nasal load is 1000 lb., composed of two men, four gas and oil and 364 lb. of surplus load.

The machine has a shade of 16,400 ft. in 20 minutes, and a speed of 120 m.p.h. Although the wings are not intended to be used, the wings themselves do not interfere with the machine's speed, so the machine's speed is not limited by the wings.

It is interesting to see the rapid wing train developed for commercial purposes.

Special Construction of School Machines

The main considerations in the construction of school, as distinct from active service and especially war machines, are:

(1) In every possibility of the parts used in the detriment of the load resistance, and

(2) Safety of construction as view of erosion

The first consideration requires that the selected parts should be as light as possible inside the wings and fuselage, that the axle should be without wood fenders and the engine mounted on only partly covered, to enable the pilot to use the working of the various parts as to facilitate repairs. Safety, which is also a consideration, is the most important, should be built in—preferably with a minimum of steel tubing as a result is unyielding and prevents rapid extrication of the victim—especially for *fracture* and *dislocation* of joints.

Institute of Aeronautical Engineers—Great Britain

Some of the objects of this institution are as follows:

(a) To promote the science, art and practice of aeronautical engineering and all branches of mechanical construction thereto.

(b) To conduct examinations and grant diplomas, including a sound classification, or grading, of aeronautical engineers.

(c) To give an impetus to inventions and investigations in the field of aeronautics, and to encourage the same to the aeronautical industry and other branches of engineering.

(d) Publicly to recognize knowledge of aeronautical science, laboratory experience, and piloting ability, as essential to the fully qualified aeronautical engineer.

The President is at present Professor G. B. Heywood, the well-known authority on theoretical aerodynamics.

Meetings are now being organized.

Membership forms may be obtained from Alexander Klossow,

22 East 42nd Street, N. Y.



Front View of the Daimler Motor L-14 Biplane

Impressions of Airplanes at the Show

By Alexander Klemin

The show is almost entirely devoted to monoplane machines, with about 70 entries of a monoplane or mixed-wing type. It demonstrates conclusively that monoplanes have now entered as a purely commercial phase, and at the same time it gives an excellent opportunity of reviewing the status of commercial design.

Commercial machines are falling naturally into certain classes, with well defined characteristics for each class. Design, square and bulbous nose, clean and aerodynamic lines, minimum temperature or all the classes exhibited, and with

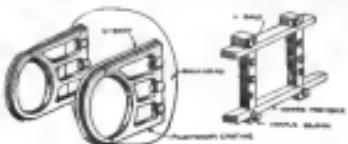


FIG. 1. LW P. BIPLANE ENGINE MECHANISM

there are no radical innovations in any class, yet there is more or less consistent progression in the general general standard of both construction and design as very much, and indicating a tremendous advance over pre-war standards. One outstanding feature of the show is compared with pre-war practice of the attention given to fuselage construction from the very first stage of the design, the correct employment of the various fuselage, and the provision of many safety fuselage accessories.

There is far more confidence in such points as well as on security and reliability than in the extreme performance and maneuverability of war types. There is also an effort on the part of manufacturers to meet the demands of the public

In the monoplane a large chord wing also is employed than in a biplane of the same type.

If these points are balanced against the simplicity of construction of the monoplane, the reduced number of exposed parts and the absence of interference between the two wings of the biplane, it may be safely said that there is very little to choose between a biplane or a monoplane, for the small type of machine.

The general appearance of the Biplane is very good and clean. In an early example of the machine the wing was carried high above the body. By keeping the wing level with the rest of the fuselage the aerodynamic efficiency increased the economy of the job, as well as simplifying the handling. It is fully to be appreciated that with the low wing loading and the low power loading the machine will have both a low landing speed and short landing run, as well as a quick getaway.

The strongly monoplane body is of the usual LW P. construction, and presents a very neat and sturdy appearance. The landing of the wing strut should be highly satisfactory. The wing lift struts are perfectly adequate in strength, as they stand, and the short struts commanding half their length



FIG. 2. WIRE TRIM OF LW P. BIPLANE

can respond promptly, and supply machines at least surface class at an extremely moderate price.

Mixed and transportation machines are distinct features of the show and show remarkable possibilities of application.

One-Place Sport Plane

A decided impression is created on the show by the LW P. Biplane, equipped with a 12 hp, 2 cyl. air-cooled motor. The little machine has a gross weight of 656 lb., a wing area of 200 sq. ft., and a wing loading of only 3.2 lb. per sq. ft. The span is 30 ft., and the overall length is 20 ft.

The machine is built very simply, and shows a certain and successful attempt to meet the demand for a low price, or, to put it simply, sporting plane.

As far as the matter of streamlining simplicity, the plane is built on a rigid truss monoplane, which carries only a minimum of parts, and a minimum of trimmings in exterior to the field. A drawback to the use of a monoplane design is a somewhat large span, which necessarily follows even with a small aspect ratio. There also follows an increase in overall length

and the wing loading.

will effectively prevent a tendency to buckling. The general scheme of the wing truss is to allow for the necessary strength. It is obvious that the length of the drag should also be ample sufficient. An external drag wire is carried on an additional staypost, from the rear seat point to the front part of the body.

On the subject of the aerodynamics of the general design, a number of interesting drag features are present. On all of the strut ends several strings are provided, so that all strings are interlinkable, with eye bolts running into head take-offs. The central drag wire is connected to both struts and to the rear seat point, which is an excellent guarantee against lateral stability by cohesion.

The engine mounting is particularly interesting. The motor is clamped between two aluminum castings by two U-bolts which fasten the motor to an aluminum bulkhead, which in turn is bolted to the fuselage frame.

Another machine in the one-place mixed plane class is the Horace Koenig model K-1, which was especially exhibited at the Field Pavilion.

The Horace Koenig model K-1 is a tractor biplane of 25 ft. span, 15 ft. 6 in. chord, and 1 ft. height. It is fitted with a 10 hp, 2 cyl. air-cooled motor, and a two-bladed, fully articulated, water-cooled type, which gives the machine a maximum horizontal speed of 80 mph and a landing speed of about 30 mph. The machine weighs fully loaded 800 lb.; the wing

loading is 4.5 lb. and the power loading 20 lb. which features should give the plane considerable maneuverability.

The wings are designed to fold back against the fuselage by removing four pins from the front and at the rear instead. The overall dimensions of the K-1 are then reduced to 2000 cu. ft. and this is a very valuable feature for storage in the machine or for transport.

The fuselage is of the four leg type, braced by knee bolts and covered with plywood sheets. It has a good streamline and a generally pleasing appearance.

The landing gear is of the V type, with a center skid to prevent nose-over.

Passenger Machines—Young Planes

In a definite class by themselves are what may be termed touring machines carrying more than two passengers. No less than three of these machines carry the Hispano-Suiza

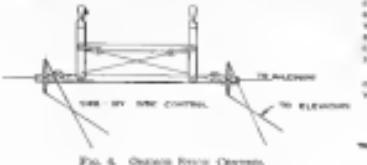


FIG. 3. CONTROL STICK OF LW P. BIPLANE

motor. Designers seem to have met the requirements for both fast and liaison because in very good fashion, and there is no doubt that machines with a pilot and two or three passengers will find a suitable market among them. There is still opportunity for the designer to experiment to the great advantage of giving the passengers a comfortable enclosed fuselage, and the disadvantages of departing the point of a certain amount of vision and feel in the air. No attempt has been made to secure great speed, these machines being used for the liaison and the like.

An entirely new machine on the show, and perhaps the most interesting of them, is the Grisiot Teaser, built by the Oklahoma Engineering Corp. The span of the wings is 28 ft., overall length 30 ft. 10 in., gross weight 3,200 lb.

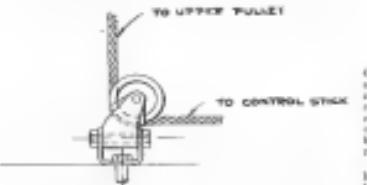


FIG. 4. GRISIOT CONTROL PULLEY ARRANGEMENT

and the wing loading is 12.5 lb. with a 160 hp Hispano. The power loading is 20 pounds per cubic foot, and the engine can cover 200 miles at the high speed of 90 miles per hour. The designer of the Grisiot has had thought to no end to the aerodynamics of the machine. They are seated side by side with the dual control in the front cockpit. The seating is very comfortable, and the machine has the conventional type. The machine has a very pleasing general appearance and is very fast and finished in design. Some features are especially noticeable.

Production possibilities have been very well taken care of. All machines are very light and are of straight section, easily taken care of by a simple frame, and the fuselage is built for the tapering effect. All the side air slots throughout the machine. The top and bottom wings are completely interchangeable. The propeller hub has been removed and is stored in the front cockpit. The wings are built in the same way in which a small boat has a clip propeller support for the central propeller. Sheet fittings are all of the single type.

The control system of the Grisiot is worth considerable attention. As shown on the sketch, the elevators and ailerons dual control is effected by a single control stick, which is very safe and maneuverable. The elevator arms also fit very well on a square tube and there is no possibility of the elevator arms shearing through small pins, or often the case.

The sketch of the control system also indicates the great economy of the aileron system. By means of four pulleys, a single 1000 ft. wire cable runs in the exact place of the control sticks, while normal all aileron arms are avoided. The design of this control system may well be appreciated upon the originality and ingenuity displayed.

The fuselage, as shown on the sketch, also gives evidence of a careful production outside. It is a popular thing how well a wide body seems to work out in a design of this type.

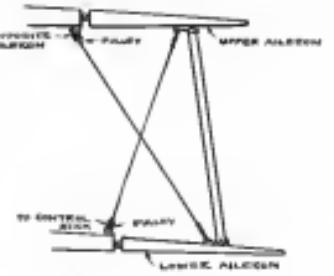


FIG. 5. GRISIOT AILERON CONTROL

Granted that a wide body means a certain amount of extra aerodynamic resistance, a number of advantages derive from it. For instance, with the ordinary width of track, the struts are straight down; the Hispano engine is completely enclosed, the engine cooling is excellent, and the weight is excellent. In general, it is quite possible that a wide body may have so many advantages that its slight increased resistance may be fully compensated for.

The engine mounting of the Grisiot Teaser is very well built. The engine mounts are secured downward at the rear ends to avoid the tendency to roll. The engine is mounted on a large base of heavy casting, together with inclined tubes, distance from the rear bulkhead to the front bulkhead, provide a mounting which should take care of wearing and other engine stresses.

The engine mounting system is simple and good. The tank is placed under the front cockpit. The tank is very large, and provides a gravity tank. The main drive pump is easily fastened to the rear cross strut and makes less of an interference than brackets generally find. The main side feed provides ample security for the pilot regarding his gasoline system.

The West Virginia Aircraft Corp. exhibited in this class of machines a three-bladed, three-bladed propeller, 160 hp. Hispano engine. The two passengers are seated almost abreast in front cockpit, while the pilot is accommodated aft. The

machines in a good solid construction, but is as standardized as it can be to fill the special contract.

The span is 44 ft. 6 in. on the upper plane and 26 ft. 8 in. on the lower plane. The overall length is 37 ft. 16 in. and the height 8 ft. 8 in. The wing areas used is termed the "West Virginia No. 1" and the surfaces are set at a negative angle of incidence of 2 deg. 30 min. and at a dihedral of 1 deg.

The machine weighs empty 1,700 lb. and fully loaded 2,600 lb. The estimated performance is as follows: maximum horizontal speed 100 m.p.h.; maximum flight speed 40 m.p.h. and climb 300 ft. per min. The wing loading is 10.6 lb. per sq. ft. and the power loading 16.6 lb. per sq. in.

The Curtiss Craft seems to be a most logical three seater ship. The pilot has a remarkable position for both where he has an excellent view and a good seat of control. The position of the front seat provided an efficient seat belt. The strength of the rear fuselage is very good, and its construction is thoroughly sound. The engine is fairly well

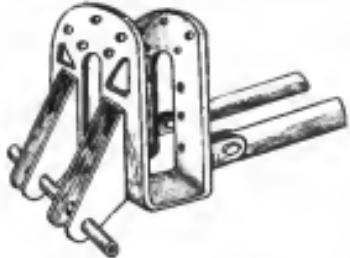


FIG. 7. CURTISS LANDING GEAR FITTING.

constructed from as much parts as possible above the fuselage, and is all the better for this, resulting, besides being readily serviceable, in a better and more reliable landing gear performance and a lower wing loading speed. It may be considered as a well designed and well balanced design.

The Bristol Fighter, which was originally exhibited at the 1913 Imperial, though a high powered machine, is equipped to carry only a pilot and a passenger. It is a very fast machine, with a maximum speed of 120 m.p.h. and a wing loading of 10.5 lb. per sq. ft. in addition to the full complement of fuel and oil. Equipped with a 220 hp. stability Poppet engine, it can obtain a maximum speed of 125 m.p.h.

The Bristol Fighter is a copy of the regular Bristol Fighter, with the exception of well known and familiar construction. It is a steady, well balanced and maneuverable machine, which should have a decided sphere of action for fast mail and freight carrying, with a lesser appeal for pleasure passenger work.

The construction of the machine is very much lighter than that of the Bristol Fighter, owing to the disappearance of the gun mount, the lowering of the rear cockpit, and the resulting improvement in the lines of the machine.

The main characteristics of the machine are: weight, empty, 1,700 lb.; span, 44 ft. 6 in.; chord, 20 ft. 2 in.; wing area, 58.6 ft. in.; overall length, 37 ft. 16 in.; landing gear load, 60 U. S. gal., sailing, 20,000 ft.

Spokane Exhibit

A very interesting machine is the Aeromarine Model 50. This is a beautifully finished construction, and is well built flying machine. Some pictures are shown of the steady engine mounting, the solid tail bracing, and the interesting seating arrangement.

This machine is illustrative of a good many instances of modern commercial design, and has very clean lines at the time time it does not depart from standard practice.

A step is provided for access into the hull, which arrangement should appeal to the public as it facilitates access and egress. The seats for the pilot and the two passengers are most comfortably upholstered. The two waistheight doors on

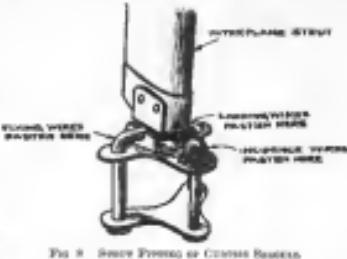


FIG. 8. FUSSELIER FITTING OF CURTISS FUSSELIER.

either side do not interfere in any way with the strength or strength of the hull. A number of small drawers and compartments are provided in front of the pilot and at the sides of the machine. The seats are so arranged as to have the proper angle of incidence, the rear cockpit being inclined by 10 deg. to which it is counterbalanced by wing incidence beneath the floor. A wheel-steering is provided, but with this important modification that the movement of the wheel is transmitted through belt gearing, a pair of shafts inside the main engine mountings and a universal joint at a horizontal shaft with a universal joint at the other end. Elevator and

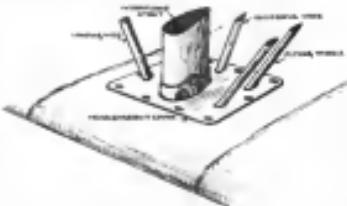


FIG. 9. TAILLESS-MORSE STRUT FITTING.

aileron control is directly achieved without a single wire connecting up the cockpit.

The fuselage and pilot seat are totally enclosed, the vision is quite good through transparent pyrex, and the pilot has a number of movable windows in front of him. A noticeable feature of the fuselage design is the distance available between the front radiator and the engine. The radiator is mounted in front of the engine.

The Curtiss Seagull is another machine of the three seater flying boat type, approximately of the same size as the Aeromarine Model 50. Equipped with a Curtiss 6 250 hp. engine, it makes a maximum speed of 70 m.p.h. and a maximum of 46.5 m.p.h. This machine is in many respects similar to the

Curtiss M.F. boats used extensively during the war for the training of Navy Aviators, and the main modification of the M.F. boats is the arrangement of the hull, in which a pilot or two passengers are carried.

The hull is provided with a much larger wind-shield than is necessary in training planes, and lots of leg-room is provided for all the occupants. A unique feature is found in the front control seats. The rear seat carries being further back on the floor than the front seat, so that the rear seat is not used as the rear control seat. This is a very clever piece of design, to get around what is always a difficult problem. It is interesting to note on this machine the use of aluminum wing bows, which come right up to the wing leading edge, and are held in place by wire cables.

In the wing roots of the Seagull it is noticeable that two large shoulder supports are provided although there is a dihedral in the machine. The E.I. truss is so arranged that the wing fittings are carried out at some distance from the hull, by

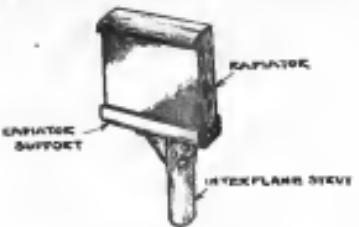


FIG. 10. ELEVATOR OF CURTISS EAGLE.

the substitution of a pair of extra struts on either side. The keel is orthogonal, which is a great advantage in the mounting of a flying boat engine.

Globe Plane

A very interesting modification of the Curtiss Eagle was exhibited at the show. Instead of the three 60-hp. motors previously installed in this plane, the Eagle now carries two Curtiss 60-hp. and one 100-hp. engine (one of the 60-hp. engines was removed) mounted on the wings.

The Eagle has a very good and well-designed plan of general arrangement, with wingless view from the front. The camouflaged fuselage, on first exhibit, was regarded with some doubt as to its aerodynamic properties, but a high speed test clearly indicates that very little detrimental effect is produced thereby.

A number of features in the construction of this ship are worthy of note. The radiator mounting is very neat, with it is generally admitted that the two are radiator is the largest in weight and aerodynamically most efficient. Designers have always found a difficulty finding a suitable place for the radiator in front of the engine. In the present design the radiator is mounted in front of the main struts supporting the engine in a very solid mounting attached to the struts. The radiator tank fits very neatly into the front edge of the upper wing. The well designed wing tanks have a suitable connection with the struts of the anti-buckling device in the struts, as is shown. No doubt the Curtiss engineers have made careful calculations in this regard, and have found advantage in lightening up the struts, even though the extra load-positions of the anti-buckling device is taken into account.

More detail has been made on the large overhang of the engine mounting, which is well necessary. This, of course, involves a slightly lower cockpit, but is obviously compensated by the balance. When three engines were employed, a similar tractor engine had previously provided the necessary balancing moment.

The fitting of the pyrex windows in the viewer fuselage is very neat, as shown in the sketch.

Another structural feature which is of interest is a clevis, with a sharp hook, which is a decided advantage in securing the front struts. The last design seems to have 40 struts on either side of the hull.

The cooling fins on the exhaust are decidedly good features, and should work very effectively.

The position of the wheels in tandem on either side is a security against nosing-over of the machine, and also pre-

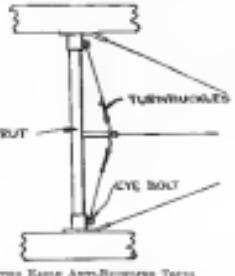


FIG. 11. CURTISS EAGLE ANTI-BUCKLING TRUSS.

vents for a very solid construction. The lagging of the cross struts on the chassis may also be a useful feature in rough landings.

Another cabin plane exhibited at the show was the Douglas Model G.W. (G.W.), a biplane of 46 ft. span and 28 ft. 9 in. overall length, which is fitted with a 150 hp. Wright-Lindbergh engine. Accommodations are provided for a pilot and two passengers and sufficient fuel is carried for a flight of 600 miles.

A noteworthy feature of the G.W. is its braced body, made necessary to pass the rear of the cabin with the upper plane. As a consequence the cabin is very spacious and the cockpit is large. The engine is mounted in front of the cabin, with a satisfactory view of the ground below, but at the same time the pilot sits in a position directly in front of the window, which is not entirely behind enticement. It is



FIG. 12. SPANWISE OF WINGSPAN OF CURTISS EAGLE.

interesting to note that the machine has a very light wing loading, only 4.6 lb. per sq. ft., and a net weight of 1,650 lb., which is good figures for a plane of this size.

From the constructional viewpoint it is rather surprising to see how hard made and unspared efforts employed in the plane. The early Douglas Wright machine, the E.T., often passes the public mind, however, as a failure. The Douglas, however, has not entirely given up, having a number of good features and is considered well built. The virtue is good and as is sometimes the case, the weaknesses are seemingly good.

The E.T. has a high initial speed of 120 m.p.h. and a low speed of 55 m.p.h. The net weight is 2,000 lb. and the gross weight 4,228 lb. The radius of action, at a cruising speed of 100 m.p.h., is 6 hr.



FIG. 11. Sun Spot at the Hertsch-Tower.

Milt and French Flours

Among the mail pieces exhibited, the Thomas Moore is an extremely interesting type, and shows considerable originality in construction and design.

In most engines the gears pass to be observed easily. A moderate amount of speed, a short landing run, a good paved road for a moderate amount of horse power, and above all, stability of the power plant to avoid forced landing in his, but also shows the oil surface precisely.

With the latter purpose in view, designers and builders
have gone to the two engine power plant. With a two engi-
ne machine, forty loads could be transported in one trip,
and with a two engine machine, a very long load could
be set up, or a case of breakdowns of one engine
can render the trip or have ample time to find a suitable
place to stop. The idea is that if one engine fails, the
other will continue to run and the machine can be set up.

Aero Show at San Francisco

The *Aeronautical Show* of San Francisco is the third of three national shows given under the auspices of the *Manufacturers' Aircraft Association*. The show will be given in the finest show building in America, the *Exposition Auditorium*, located five minutes' walk from the business center of *San Francisco*.

The following are a facsimiles of signatures from subscribers for reprint, to date:

PHOTO COURTESY OF B. BOYD CHIP
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Division Manager, Dept. of General Merchandise

It is anticipated that the main floor exhibition space will be overwhelmed. The Pacific Coast office a splendid display for permanent attorney lines, and an exhibit at the Show.

Colonel Miller Change Station

The mail that carried Col. Archibald Miller from Macon on his way to assume command of Kelly Field, Texas, was probably half a dozen packages or more of horses. The pilots flew the mail in the rear of the plane, and the horses, in the front, were to be used for the horses of the entire Army.

over and around the town almost the entire distance to New York City.





A Gigantic Sale Surplus War Material Which Has Passed Government Inspection

The Shipbuilding program of the United States Government was so enormous in scope and stupendous in accomplishment that the ending of the war found us with surplus material of practically every description in stock, ready to be used, but for which there was no further Governmental use.

This Is Now For Sale and Must Be Disposed of

From individual houses to entire villages and housing operations; from ship buckets to complete ship equipment—the range of offerings runs.

There will also be found—Structural steel, fabricated in complete units for concentration passenger and cargo 8000 tons D. W. capacity steel ship hulls, and several thousand tons structural steel both fabricated and unbonded for other than steel hulls; Engines and Engine Auxiliaries, Boilers and Accessories; Condensers, Tanks and Evaporators, with their fittings, Stays and Deck Equipment; Electrical Apparatus from Generating Outfits and Transformers to Wires, Cables and Batteries; 'Carpenters', 'Enginemen', 'Mechanics' and Firemen's tools—Blocks, Cranes, Derricks and Buoys in enormous quantities and sizes; Refrigerating Outfits and Machinery; Life Boats and Life Rafts; Boiling Water Systems; Air Rrovers; Boreholes and straight Drills; Machinery, Foundry and Machine Tool Equipment; Air Compressors and Pneumatic Tools; Railroad Equipment and Piping (horizontal, vertical, vertical); Pipes, Valves and Fittings; Nets and Bells; Seaworthy Towing of Cables and Steel and a variety of other equipment and material too numerous to mention.

Everything has been inventoried, showing the article, their number with a detailed description, as well as appraised value. All material has passed Government inspection and is now in warehouses at concentration yards.

*Buyers for entire lots of material and equipment
at any of the concentration points will receive first
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Inspection is invited and can be arranged for by addressing:
Sales Section, Supply and Sales Division, United States Shipping Board, Emergency Fleet Corporation, 6th and B Streets, Washington, D. C., or any of the following offices sales and sales offices:

339 Center St., New York City
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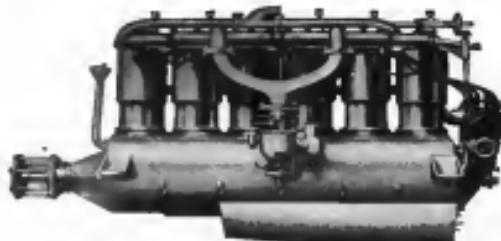
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